Use of Frequency Response Metrics to Assess the Planning and Operating Requirements for Reliable Integration of Variable Renewable Generation

Prepared for
Office of Electric Reliability
Federal Energy Regulatory Commission

Prepared by
Joseph H. Eto, Principal Investigator
Lawrence Berkeley National Laboratory

Project Team
John Undrill, John Undrill, LLC
Peter Mackin, Ron Daschmans, Ben Williams,
Brian Haney, Randall Hunt, Jeff Ellis, Utility Systems Efficiencies, Inc.
Howard Illian, EnergyMark, Inc.
Carlos Martinez, Electric Power Group, LLC
Mark O'Malley, University College Dublin
Katie Coughlin, Kristina Hamachi-LaCommare, Lawrence Berkeley National Laboratory

Frequency Response Impacts of Variable Renewable Generation

1. Will Lower System Inertia – *requires increased reserves for primary frequency control*

2. May Displace Primary Frequency Control Reserves – *requires procedures for ensuring adequate reserves for primary frequency control*

3. May Affect the Location of Primary Frequency Control Reserves – *requires consideration of transmission system limits and deliverability of primary frequency control actions*

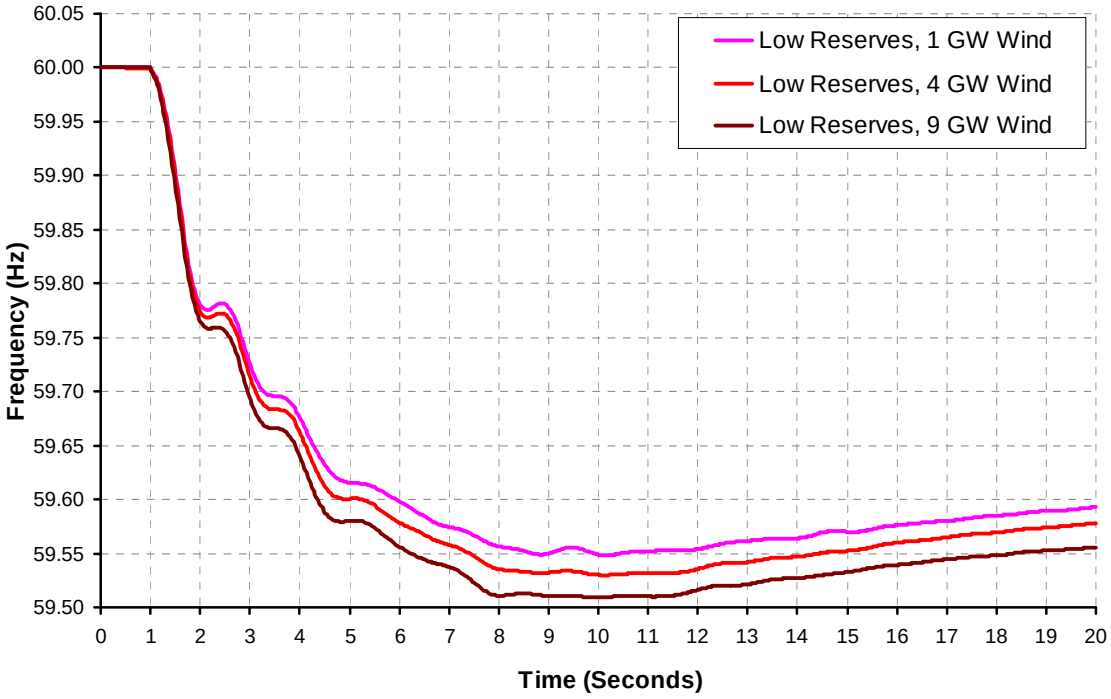
4. Will Place Increased Requirements on the Adequacy of Secondary Frequency Control Reserves – *requires better forecasting and improved operating practices*

Note: The rapid ramping of variable renewable generation output is not considered a frequency response event comparable to the sudden loss of conventional generation – but rapid ramping represents an important new operating challenge directly related to Impact 4

Simulation Findings

For the Western Interconnection, assuming operating reserve conditions that are representative of current practices and that are used in daily operations (which are higher than the minimum levels that are allowable under current operating procedures), our simulation studies confirm that the interconnection can be reliably operated with the amount of wind generation and supporting transmission expected by 2012.

The system model we studied included 9 GW of installed wind generation capacity, which based on an assumed 35% capacity factor could supply approximately 3 percent of the interconnection's expected electricity requirements in 2012.

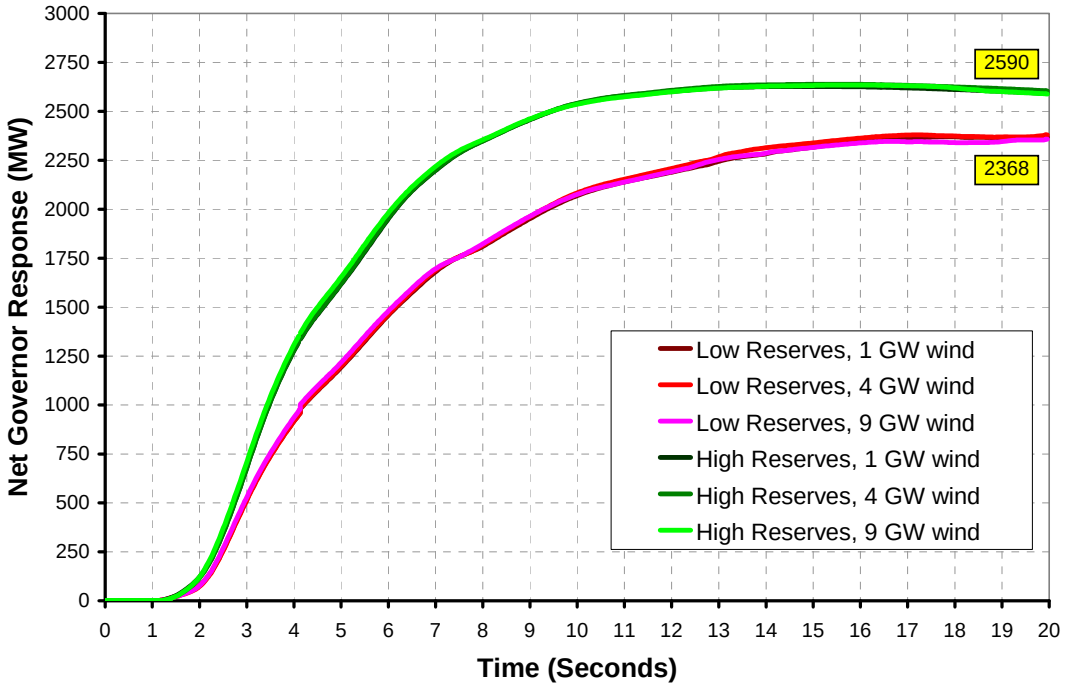


Simulated Western Interconnection System Frequency Over the First 19 Seconds Following the Sudden Loss of the 2,800 MW Generation for the Low Reserves Cases

Simulation Findings

A principal finding from our simulations of the Western and Texas Interconnection is that the rapid delivery of power via primary frequency control actions is more important than the amount of wind generation in determining the frequency nadir. The effect of increased wind generation in lowering system inertia is not significant compared to the effects of primary frequency control actions.

The simulations also suggest that focused attention on the quality of primary frequency control actions, provided by generator governors and, in the Texas Interconnection, frequency-responsive demand response, can readily off-set the effects of increased wind generation on system inertia.



The Power Delivered by Primary Frequency Control Actions via Generator Governors in the Low and High Reserves Cases for the Western Interconnection